DYED FABRIC MATERIAL, METHOD OF PRODUCING THE SAME AND USE OF THE FABRIC MATERIAL IN THE MANUFACTURE OF SPORTS BALLS

The present invention relates to fabric material particularly suitable for the manufacture of sports balls and to a method of obtaining the same. More particularly it relates to a new method of dyeing woven or not woven material which provides the material with high visibility characteristics. The invention also relates to the dyed material thus obtained and to the use of such material for the manufacture of sports products and particularly for the covering of tennis balls.

Traditionally, tennis balls were covered with white woollen felt. Several decades ago yellow felt was introduced for use on match quality balls and from the early 1970's balls covered with yellow felt became increasingly popular. Today, the vast

majority of tennis balls are covered with yellow felt. Rule 3 of the International Tennis Federation Rules of Tennis states "The ball shall have a uniform outer surface consisting of a fabric cover and shall be white or yellow in colour...".

The felt used on tennis balls was previously made from wool. Increased wear properties are obtained by including a proportion of synthetic fibres in the felt, and nowadays such felt is usually made of a mixture of wool and nylon fibres. The proportions of wool and synthetic fibres used to produce the felt can vary, but typically a ratio of 40:60 to 60:40 can be used (by weight of weft yarn). It is desirable that the side of the felt termed the "back" (which is the side which will be stuck to the ball) is made of a material which provides good adhesion when it is glued on the internal rubber sphere of the ball. Usually the backing is formed by using 100% cotton warp yarns, but alternatives such as polyester and nylon could be used.

The tennis ball felt is then preferably dyed with a fluorescent dyestuff. That is, the coloured felt will absorb ultra-violet light and re-emit the absorbed energy in the visible area of the spectrum. Most tennis balls are now covered with felt that is dyed fluorescent yellow and which produces peak reflectance values of over 100% in the yellow area of the spectrum.

Few manufacturers produce fluorescent dyestuffs suitable for both wool and polyamide fibres. To the best of the Applicant's knowledge all the major tennis ball felt manufacturers use the same class of dyestuff albeit from different dyestuff suppliers. This class of dyestuff gives a hue (colour) slightly to the green side of yellow.

The cones in the human eye are mainly responsible for daylight colour vision and these give the eye the highest visual efficiency in the yellow wavelengths. In addition to percentage reflectance three other values can be plotted to identify a colour:

Lightness, with a scale of 0 to 100, 0 being black and 100 white;

Hue, which can be shown as a circle with red at 0 degrees and yellow, green and blue at 90 degree intervals from this, the exact angle therefore indicating the hue. If the lightness is visualised as a vertical axis passing through the centre of the hue circle, then a colour can be plotted in three dimensional space; and

Chroma or colour saturation which can be shown as the distance along a given radius from the centre of the hue circle.

In the mid 1990's a high visibility yellow felt (or Hi.Viz. F/Y) was produced using an increased

percentage of dyestuff. This felt (or Hi.Viz. F/Y) has a higher level of saturation (chroma) but actually has a slight reduction in peak reflectance and in lightness when compared to some standard coloured felt.

A method has now been found which allows the production of coloured felt for tennis balls having enhanced visibility properties over the prior art.

The invention also provides a method of dyeing material which produces an Ultra High Visibility (UHV) felt which mitigates shortfalls of previously available dyed felts.

More particularly, the invention provides a method of dyeing fabric material (particularly fabric material which is suitable for use in sports ball manufacture) which method comprises contacting said fabric material with a bleaching agent prior to or simultaneously with contacting said fabric material with a dyestuff providing said colour. The term "fabric material" includes both piece goods, yarns and also fibres in loose form.

The present invention is based on the fact that the felt used to produce tennis balls typically has a significant wool content (usually 40% or higher). However, the peak reflectance of natural wool fibre in the yellow area of the spectrum is typically around 75% due to the natural yellowish-tinge in even

the whitest wool. By means of comparison, titanium dioxide treated nylon would typically have a 90% reflectance. We have found that the naturally low reflectance of wool limits the reflectance achievable even with a fluorescent dye.

The need to bleach a yellowish-fibre (natural wool) prior to or during dyeing that fibre yellow appears counter-intuitive, but we have found that the performance of the dye applied is greatly enhanced by this step.

Preferably the material to be dyed is a felt and especially a woven felt.

Preferably the material to be dyed comprises a mixture of fibres of different types, for example, a mixture of wool and synthetic (e.g. polyamide or polyester) fibres. Preferred synthetic fibres are polyamide fibres, for example Nylon 6,6 or Nylon 6. We have found Nylon 6,6 to be most suitable. One or more different synthetic fibres may be present in the fabrics material.

The proportions of wool and synthetic fibres may vary according to the consumer's requirements on cost and performance of the fabric material. For woven fabrics having warp and weft yarns, a wool content of at least 20% (usually 25%) by weight of weft yarn is required.

We have found that better quality fabric material is achieved with increased wool content - for example 30% or higher by weight of weft yarn. Typically a wool content of 40% or above, for example 50% or 60%, by weight of weft yarn achieves good results. It may be desirable to use fabric having a wool content of over 45% by weight of weft yarn and in certain high quality fabric materials, like those used for high quality tennis balls, over 50% (usually around 60%) is used. In some cases the wool content may be even higher (e.g. over 65% or 70% by weight of weft yarn) and be 80% or over.

For woven fabric, the warp yarn will typically be a cotton yarn, but polyester or polyamide (e.g. nylon) could alternatively be used. For non-woven fabrics (e.g. needlefelted fabrics) or knitted fabrics a lower wool content (for example in the range of 20-40% by weight, preferably at least 25%) may be sufficient. By "wool" we include wool-like fibres (e.g. angora, cashmere and mohair) as well as the more typical sheep's wool.

Nylon fibres having a circular cross-section have been successfully used, but synthetic fibres having other cross-sections (e.g. triangular or flattened) are commercially available and may further increase the reflectance achievable.

It is also preferred that the material is processed as described in piece form. Preferably the fabric is

a felt and more particularly a felt suitable for the covering of tennis balls. Since a mixture of fibre types (wool and synthetic) are present in the fabric material, it is recommended to contact the fabric material also with a partitioning agent in order to eliminate or reduce the difference in uptake of the dyestuff between the different types of fibres. The bleaching agent, which is preferably a reduction bleaching agent, whitens the initial colour of at least the wool.

Preferably the fabric material is treated using a jet-dyeing apparatus and a liquor ratio of 6:1 to 8:1 is used to run the machine.

It is further preferred that the pH is adjusted preferably between 4.2 and 4.5 by using, for example, formic acid. The temperature is then raised to a suitable temperature, for example about 45°C, and held for a period of, typically, 3 minutes to be able to check and if necessary adjust the pH.

A wide range of suitable partitioning agents are available depending for example upon the nature of the material to be treated. However the partitioning agent sold under the Trade Name BASOPAL NA by BASF plc of Cheshire, SK8 6QG, United Kingdom, has demonstrated good results. BASOPAL NA is an alkylarylsulphonate in water and comprises 50-60% by weight of the salt of dodecylbenzenesulphonic and triethanolamine. The concentration of BASOPAL NA

recommended is about 0.5 grams per litre of liquor. Alternative partitioning agents include THIOTAN RMFN LIQUID (an anionic sulphated fatty acid, pH 7 to 8 at 10% dilution) to be used at a concentration of 3.0 to 0.1% (o.w.f.); and ERIONAL RF of Ciba Speciality Chemicals Inc, Basel, Switzerland (an anionic condensation product of aromatic sulphonic acids and formaldehyde, pH 3.5 at 5% solution) to be used at a concentration of 0.5 to 6% gram per litre liquor.

It is further preferred that the bleaching agent and, if appropriate, the partitioning agent be in contact with the material for a reasonable length of time (typically from 1 to 30 mins) prior to the dyeing step being executed.

It is further preferred that the bleaching agent be added simultaneously or quasi-simultaneously with the partitioning agent.

The bleaching agent preferably used is the one sold under the Trade Name LUFIBROL FW by BASF plc of Cheshire, SK8 6QG, United Kingdom. LUFIBROL FW is an inorganic reducing agent with chelating agents and comprises 30-40% by weight tetrasodium ethylene-diaminetetraacetate and 30-40% by weight disodium disulphite. The amount of LUBRIFOL FW used is advantageously about 2% of the weight of fibre. Alternative bleaching agents include LANALBIN BE powder (a non-ionic hydroxylamine derivative, pH 5.6-5.7 at 1 g/litre) to be used at a concentration of

1.0 to 4.0% (o.w.f.); and ERIOCLARITE B of Ciba Speciality Chemicals Inc of Basle, Switzerland (an anionic mixture of sodium metabisulphite with the sodium salt of ethylenediamine tetraacetic acid, pH 6 at 5% solution) to be used at a concentration of 0.5 to 1 g/litre.

It is preferred to use a fluorescent dye.
It is further preferred to use a yellow dye, as this colour is highly desirable for the manufacture of tennis balls. The preferred yellow dye which can be used according to the invention is a dye having a colour index number acid yellow 250, for example the one sold under the Trade Name NYLOMINE FLAVINE C-7G dyestuff by BASF plc, of Cheshire, SK8 6QG, United Kingdom. The dyeing step can be performed according to the recommended practice. A typical method is to add the dyestuff to the material and the liquor according to a recommended concentration and the temperature is then raised to the recommended level and held for some time at this temperature before rinsing.

The method of the invention also provides a white fabric material having enhanced visibility properties. The method is similar to that described above except that the "dyestuff" referred to is an optical brightening agent. Optical brightening agents are commonly used in the dyeing industry. The brightening agent sold under the trade name UVITEX

NFB by Ciba Speciality Chemicals Inc of Basle, Switzerland can advantageously be used.

The invention also relates to the dyed material, preferably a felt, and more preferably a woven felt, obtained according to the method of the invention which is coloured, preferably in yellow, and displays enhanced visibility properties.

The invention further relates to the use of coloured fabric material dyed according to the method of the invention in the manufacture of articles such as sporting articles and more particularly tennis balls.

The invention further relates to sporting articles comprising the dyed fabric material, and more particularly to sports balls (in particular tennis balls) covered with such material.

The present invention provides a fabric material suitable for use in sports ball manufacture, wherein said material includes wool fibres and exhibits the following characteristics:

a) for a coloured (non-white) fabric material:

i) a chroma value of 100 or more;
ii) a lightness value of 95 or more; and
iii) a reflectance value of 120 or more, or

b) for a white fabric material:

i) a chroma value of 14 or less;

ii) a lightness value of 85 or more; and

iii) a reflectance value of 100 or more.

When the dyed material is a woven fabric having warp and weft yarns, a wool content of at least 20% (usually 25%) by weight of weft yarn is required. Desirably, the wool content includes at least 30% or more, preferably 40% or more, by weight of weft yarn. It may be desirable to use fabric having a wool content of over 45% by weight of weft yarn and in certain high quality fabric materials, like those used for high quality tennis balls, over 50% (usually around 60%) is used. In some cases the wool content may be even higher (e.g. 65% or 70% by weight of weft yarn) and be 80% or over.

For non-woven fabric the minimum amount of wool required is about 20% by weight. Desirably, the wool content includes at least 30% or more, preferably 40% or more, by weight. It may be desirable to use over 45% by weight of wool and in certain high quality fabric materials 50% by weight of wool, or even 60% by weight of wool (e.g. 65% by weight of wool or even up to 70% by weight of wool) may be employed.

For a coloured (non-white) fabric material the chroma value may be higher than 100 (for example 102 or more, preferably 105 or more) and, generally, a high chroma value is desirable provided that the minimum lightness and reflectance values given above for a

coloured (non-white) fabric material are maintained. We have achieved a chroma value of over 110, specifically a value of 113.4.

Likewise, for a coloured (non-white) fabric material a lightness value of greater than 95 is desirable (for example of 96 or more, or even 97 or more) provided that the minimum chroma and reflectance values given above for a coloured (non-white) fabric material are also maintained.

Similarly, for a coloured (non-white) fabric material a reflectance value of over 120 (for example 125 or more, preferably 128 or more) is desirable provided that the minimum lightness and chroma values given above for a coloured (non-white) fabric material are also maintained. We have achieved a reflectance value of over 129, specifically a value of 129.9.

In a preferred embodiment, the coloured (non-white) fabric material according to the present invention exhibits the following characteristics:

i) a chroma value of 105 or more (preferably 110 or more);

ii) a lightness value of 96 or more (preferably 97 or more); and

iii) a reflectance value of 125 or more (preferably 128 or more).

Preferably the coloured (non-white) fabric material is a yellow material.

For a white fabric material, the chroma value is desirably lower than 10 (for example is 8 or less, preferably is 5 or less) and, generally, a low chroma value (indicating absence of colour) is desirable provided that the minimum lightness and reflectance values given above for a white fabric material are maintained.

Likewise, for a white fabric material a lightness value of greater than 85 is desirable (for example of 88 or more, 89 or more, or 90 or more) provided that the maximum chroma value and minimum reflectance value given above for a white fabric material are maintained.

Similarly, for a white fabric material, a reflectance value of over 100 (for example 102 or more, 105 or more or 106 or more) is desirable provided that the maximum chroma value and minimum reflectance value given above for a white fabric material are maintained.

In a preferred embodiment, the white fabric material according to the present invention exhibits the following characteristics:

i) a chroma value of 8 or less (preferably 5 or less);

ii) a lightness value of 92 or more (preferably 93 or more); and

iii) a reflectance value of 85 or more (preferably 90 or more).

The present invention further provides a sports ball having a fabric material surface (for example a tennis ball) wherein said sports ball is manufactured using a fabric material as defined above.

In a further aspect, the present invention provides a sports ball having a fabric material outer surface (for example a tennis ball) wherein said fabric material forming said outer surface includes wool fibres and exhibits the chroma, lightness and reflectance value described above.

In a further aspect, the present invention provides a sports ball having a white fabric material outer surface (for example a tennis ball) wherein said fabric material forming said outer surface includes wool fibres and exhibits the following characteristics :

i) a chroma value of 10 or less;
ii) a lightness value of 90 or more; and
iii) a reflectance value of 80 or more.

When the dyed material is a woven fabric having warp and weft yarns, a wool content of at least 20% (usually 25%) by weight of weft yarn is required. Desirably, the wool content is at least 30% or more, preferably 40% or more, by weight of weft yarn. It

may be desirable to use fabric having a wool content of over 45% by weight of weft yarn and in certain high quality fabric materials, like those used for high quality tennis balls, over 50% (usually around 60%) is used. In some cases the wool content may be even higher (e.g. over 65% or 70% by weight of weft yarn) and be 80% or over.

For non-woven fabric the minimum amount of wool required is about 20% by weight. Desirably, the wool content includes at least 30% or more, preferably 40% or more, by weight. It may be desirable to use over 45% by weight of wool and in certain high quality fabric materials 50% by weight of wool, or even 60% by weight of wool (e.g. 65% by weight of wool or even up to 70% by weight of wool) may be employed.

For a white fabric material, the chroma value is desirably lower than 10 (for example is 8 or less, preferably is 5 or less) and, generally, a low chroma value (indicating absence of colour) is desirable provided that the minimum lightness and reflectance values given above for a white fabric material are maintained.

Likewise, for a white fabric material a lightness value of greater than 90 is desirable (for example of 92 or more, 93 or more, or 94 or more) provided that the maximum chroma value and minimum reflectance value given above for a white fabric material are maintained.

Similarly, for a white fabric material, a reflectance value of over 80 (for example 85 or more, 90 or more or 95 or more) is desirable provided that the maximum chroma value and minimum reflectance value given above for a white fabric material are maintained.

In a preferred embodiment, the white fabric material according to the present invention exhibits the following characteristics:

i) a chroma value of 8 or less (preferably 5 or less);
ii) a lightness value of 92 or more (preferably 93 or more); and
iii) a reflectance value of 85 or more (preferably 90 or more).

The invention as described above with reference to coloured (non-white) fabric material (both in respect of the fabric material per se and in respect of the sports ball having a fabric material outer surface) preferably refers to a yellow fabric material. References to "yellow" refer to any non-white fabric material which is acceptable to the International Tennis Federation (I.T.F.) (since yellow is an accepted coloration of tennis ball according to the I.T.F.). However, this is not exclusive, and other coloured fabric materials (for example pink, green, blue, etc) are also encompassed.

The present invention will be now further described with reference to the following, non-limiting example and Figures in which:

Figure 1 shows the reflectance curves of two prior art felts in ball form (Nos 2 & 3) compared with the Ultra High Visibility yellow felt (UHV F/Y) in fabric form (No 1) of the invention.

Figure 2 shows the reflectance curves of two other felts (Nos 4 & 5) produced by the Applicant and compared with the UHV F/Y felt (No 1) of the invention, all in fabric form.

Figure 3 shows the same data as Figure 2 but the data used to produce the curves are generated by the International Tennis Federation on their spectrophotometer.

Figure 4 shows the saturation (chroma) of the UHV F/Y felt (No 1) of the invention compared with the four prior art felts (Nos 2 to 5) used in Figures 1 to 3.

Figure 5 shows the lightness of the same five felts used in Figure 4.

Figure 6 is an attempt to illustrate the position on the colour circle by both chroma and hue of the five samples used in the comparative data shown in Figures 1 to 5.

Example 1

Production of an ultra high visibility yellow felt according to the method of the invention

The felt used in this example is a fabric material having an back surface made mainly in cotton and a face side made of a wool and polyamide fibre felt (the face side of the fabric forms the external face of the ball). Only the face surface made of wool and polyamide felt needs to be coloured. Wool and polyamide are present in the weft in a ratio of about 60:40 with respect to the weight of wool and polyamide fibres. The amount of cotton fibres in the material represents about 15 % of the total weight of the fabric material.

The felt is dyed using acid dyes in piece form using a Softflow jet dyeing machine which is run at a liquor ratio of between 6:1 and 8:1. The liquor is the liquid in which the material is wetted before the addition of the dyestuff. In most cases and in particular in this example the liquor is water.

The dyeing method used in this example is as follows:-

- The felt is entered into the machine cold and the liquor ratio as indicated above;
- The pH is adjusted between 4.2 and 4.5 with formic acid;
- The temperature is raised to 45°C and held for 3 minutes whilst checking pH;

- 0.5 grams per litre of BASOPAL NA (BASF) and 2% by weight of fibre of Lufibrol FW (BASF) are added through the dosing system; and
- the machine is run for 5 minutes at 45°C.

The following dyeing method is then applied:

- 1.6% by weight of fibres of NYLOMINE FLAVINE C-7G dyestuff is added through the dosing system during a period of 2 minutes;
- the temperature is raised at a rate of 1.8°C per minute to 95°C and the machine is run for 30 minutes at this temperature;
- the temperature is decreased to 40°C at a rate of 2.5°C per minute; and
- the felt is rinsed twice with fresh water and unloaded from the machine.

Comparative data

The colour characteristics of the felt dyed according to the above described method are shown in Figures 1 to 6. Except for Figure 3, all data were measured by the Applicant using CIE (Commission Internationale d'Eclairage) CIELAB formula at a 10 degree reflectance angle using standard D65 illuminant.

Figure 1 shows reflectance curves of an UHV yellow felt (UHV F/Y) made according the method described in Example 1 and of two competing felts in the form of tennis balls produced respectively for the companies Tretorn Sport and Penn Racquet Sports under the Trade Names TRETORN TXT and PRO PENN. The felts used to

cover these balls are produced by Textech Industries. We have found only minimal difference in the spectrophotometric measurements made between a fabric in sheet form and the same fabric when in the form of completed tennis balls.

Figure 2 shows reflectance curves of the UHV F/Y felt used in Figure 1 and of two other yellow felts, a "standard" (Std.F/Y) one and an "high visibility" one (Hi. Viz. F/Y), both produced by the company Milliken (Woollen Speciality Products) under the respective Trade Names PLAYNE'S 14 and PLAYNE'S 45. These felts are used in the manufacture of tennis balls such as the ones sold under the Trade Names DUNLOP FORT (standard) and SLAZENGER WIMBLEDON (high visibility).

Figure 3 shows the same data as Figure 2 but the data used to produce the curves are generated by the International Tennis Federation (ITF) on their spectrophotometer. This independent measurement shows good correlation with the Applicant's own data.

Figures 4 and 5 show respectively the chroma and the lightness of the five tested felts.

Figure 6 shows a graph displaying the combination of both chroma and hue performances of the five tested felts.

As can be seen from Figures 1 to 6, the colour of the felt of this example of the invention demonstrates

superior characteristics in all areas (i.e. chroma, hue lightness and reflectance). The performances, when compared to the closest prior art (i.e. the High Visibility felt manufactured by Milliken), are especially better for lightness and reflectance.

Figures 2 to 4 & 5 show that the high visibility felt has a higher level of saturation (chroma) but actually has a slight reduction in peak reflectance and in lightness when compared to the standard colour felt. This disadvantage does not exist with the colour of the UHV felt.

A summary table of the peak reflectance level, chroma, hue and lightness for the fabric according to the invention (UHV F/Y) and for the commercially available alternatives used above and a natural white tennis ball felt is given in Table 1 below.

Table 1

Product	Peak Reflectance Level	Chroma (Saturation)	Hue	Lightness
Natural White Tennis Ball Felt	78.46	8.9	92.4	87.8
Milliken Standard Yellow Felt (Std.F/Y)	122.4	98.2	108.8	96.5
Milliken High Visibility Yellow felt (Hi.Viz.F/Y)	119.8	112.0	101.3	94.2
UHV F/Y	129.9	113.4	104.7	97.9
Tretorn TXT Ball	113.1	100.9	104.5	93.6
Pro Penn Ball	124.4	95.8	108.1	95.7

Thus, the UHV F/Y felt of this invention can be used for the manufacture of yellow tennis balls of improved colour properties, which is obviously highly desirable to tennis players. Such improved properties permit, during a game, a more easy and rapid catch (visualisation) of the incoming moving ball by the tennis player and thus a quicker reaction and positioning of the player with respect the ball.

The method and the product thus produced according to the invention may be used for other purposes than covering tennis balls. The high visibility of colour material of the invention could also be used for producing other items than tennis balls, especially those where high visibility is important (for example footballs - especially for indoor use - basketballs and volleyballs).

Alternative dyeing technologies may be used, and specific mention may be made of the following:

1. Winch beck

Winch beck dyeing is an alternative technology for dyeing piece goods and pre-dates the Softflow jet-dyeing apparatus. Whilst the dyeing method is essentially the same as for jet-dyeing the liquor ratio would be higher, normally 20:1 to 25:1.

In simple terms, this is a vertical stainless steel tank; the top half of one side lifts up and down for

access and the top is vented. A large roller known as a winch is contained within the top section. There is a heating coil in the bottom section.

The tank is partially filled with water and the cloth is then passed over the winch roller, through the water and then back out of the machine. The two ends of the cloth are sewn together to make an endless rope. The winch is driven to continually rotate the rope through the water.

Dyes and chemicals are pre-dissolved and then added to the water. Steam is passed through the heating coil to raise the bath temperature to 98°C. This temperature is held for 30-45 minutes, after which the tank is cooled by filling with cold water and then draining. This is repeated until a safe handling temperature is achieved after which the cloth is removed.

Products used in the bath:

Fluorescent yellow dyestuff - colouring material.
Glauber salts - acts as a levelling agent.
Formic acid - to lower the pH making the cloth more attractive to dyestuff.

2. Loose stock machine

This is a circular stainless steel tank (or vat), from 1 metre to 3 metres diameter, which is partially

filled with water. The material, in the form of loose wool and/or nylon fibres, which have been pre-washed is loaded into a cage. This cage then has a lid attached and is placed inside the outer tank. Dyestuff and chemicals are pre-dissolved inside a header tank and then pumped into the tank and through the stock in the cage.

The temperature of the vat is raised to 98°C and held for 30-45 minutes. The dye liquor is drained and fresh cold water pumped through to rinse and cool the loose stock.

The products used are the same as for winch dyeing.

After dyeing the fibres are processed into fabric form.

3. Package dyeing

Yarn is wound onto a stainless-steel cylinder which is perforated, allowing the dyeing liquor to be pumped through the yarn package from inside to out and vice versa. The yarn package is loaded into a circular, stainless steel tank and then pre-dissolved dyes and chemicals are pumped in.

The temperature of the liquor is raised to 98°C by a steam heating coil. This temperature is maintained for approximately 1 hour. The packages are then rinsed with cool water to cool the bath and remove

residual dyestuff. The batch is left to drain and then removed from the vessel.

Products used are the same as for winch dyeing.